STUDIES ON THE SPOTTED BOLLWORMS OF COTTON—*EARIAS FABIA* S., AND *E. INSULANA* B.

BY

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Cotton buds and bolls are subject to varying degree of damage by caterpillars of *Earias fabia* S, *E. insulana* B, *Platyedra gossypiella* S, *Heliothis armigera* F and *Rabila frontalis* W. In Coimbatore, the latter two do occur but in such sparse numbers and at only certain periods of the growth of cotton that they had at no time gone beyond the stage of minor pests, though in countries like *America* and *South Africa Heliothis armigera* F had easily attained the rank of one of the serious major pests of cotton. Caterpillars of *Earias fabia, E. insulana* and *Platyedra gossypiella* are easily the most destructive and cause considerable damage to the growing buds and bolls. Fletcher and Misra (1921) have given an account of the former but it relates mostly to the pest as prevalent in N. India. Recently, Deshpande (1936) has made a valuable contribution on the spotted bollworms as far as they relate to Bombay. As yet there has been no published record of the spotted bollworms relating to S. India which would give a connected account of the worms as they prevail in the south. The need for such a contribution is obvious and an attempt is made in this paper to supplement the knowledge in that direction. This paper exclusively deals with the spotted bollworms under Coimbatore conditions.

SEASONAL INCIDENCE

(*a*) *General.* The cotton season starts from September-October months when both Cambodia and rainfed cottons are usually sown. The indications of borer attack are first discernible in November when the affected top shoots show signs of withering. The spotted bollworms as they try to make their way into the stem and branches through the axillary and apical buds cause destruction to the latter. They feed on the core of the stems and this results in growth ceasing altogether above the region of damage. It is claimed that this kind of damage does really good to the plant in certain types of cottons by accelerating the production of monopodials on a more extensive scale. Venkataraman and Jagannath Rao (1933) had experimentally proved that such damage to the 'Northerns' in Nandyal tract had given significant increased yield in the plants so

affected by top borers. Similar studies, however, made by Ramanathan (1931) in Cambodia and Uppam had given negative results. Though one should welcome an attack of this kind in certain types of cotton, there is always the inherent danger of this kind of initial infection gathering strength and bringing about considerable loss of buds and bolls at the time of heavy budding and bolling. From the stems the caterpillars turn over to the buds and bolls as they begin to appear in late November. Of the two kinds of spotted bollworms that are found here, *Earias fabia* occurs in preponderent numbers unlike in the *Punjab* where *E. insulana* is said to be the most abundant. The latter sometimes appears now and then in the season in cotton buds and bolls but never shows up prominently.

(*b*) *Shed buds and bolls.* Hilson, Ramanatha Ayyar and Chockalingam Pillai (1925) have recorded that the majority of the buds and bolls shed were apparently healthy, unaffected by pests and diseases, and those that were attacked by insects traceable to spotted bollworm damage. It was gathered from their studies that the peak attack was reached in December with 65% damage to the buds and bolls, and thereafter the incidence took a downward trend and touched a very low figure of 5% by the middle of February; again it went upto 20% in May. Attempts were made to study the incidence in the shed buds and bolls of Cambodia of borer attack on a wider basis with a larger material to work on. The work was continued over a period of three seasons in the years 1937-38, 1938-39 and 1939-40. The shed material was daily picked together in the mornings from a plot of two cents and examined the same day for borer incidence. Sometimes the studies had to be suspended due to dearth of material in the field and were resumed when they became available again. The data thus obtained are presented in the Table I.

It will be observed that the caterpillar population was very high from the middle of December to the first week of January in 1937-38 and this period of intense activity of the bollworms coincided with the maximum damage to the buds and bolls and the heavy shedding noticeable then. Thereafter there was seen an abrupt falling off in the population followed by a slowing down of shedding and a decrease in the extent of bollworm damage therein. There was also observable a tendency for the population to rise again in the middle of May to July when shedding became prominent again and the damage pronounced. But in 1939 similar trends were not observable; there was very little of shedding in the months preceding February, and the caterpillar activity as judged from the population percentage would appear to be comparatively low. The maximum percentage of damage and population had never exceeded 2·8 and 1·5 in buds and 3·76 and 2·06 in bolls in the month of February when shedding was most heavy. But in the previous year, i.e., 1937-38, the period of heavy shedding and damage had commenced rather early and the maximum percentages of damage and popu-

TABLE I

Percentage of incidence of spotted bollworm damage and population in Cambodia shed cotton.

Year	Buds					Bolls				
	Total examined	Damaged by Earias	Larval population	% age of damage	% age of population	Total examined	Damaged by Earias	Larval population	% age of damage	% age of larval population
1937										
Novr. ii.	679	344	3	50·7	0·5	313	171	23	55·0	7·3
Decr. i.	4203	1600	452	38·0	10·7	6137	2084	715	33·9	11·6
,, ii.	2373	340	57	14·4	2·4	13827	1422	320	10·3	3·3
1938										
Jan. i.	2154	60	6	2·8	0·3	20431	459	60	2·2	0·3
,, ii.	222	19	—	8·6	—	2757	131	11	4·7	0·4
Feb. i ,, ii	..... no shed material									
Mar.	..... no shed material									
Apr. ii.	127	7	—	5·5	—	84	1	1	1·2	1·2
May. i.	1507	418	60	27·8	4·0	788	73	36	9·2	4·5
,, ii.	7917	548	115	6·9	2·0	1597	359	174	22·0	10·9
June i.	3419	835	211	24·4	6·2	1683	720	361	44·0	21·5
,, ii.	228	103	44	45·0	15·0	461	148	65	32·0	14·1
July i.	896	357	162	39·9	18·2	277	87	71	31·0	25·8
,, ii.	1276	241	97	18·8	7·6	533	163	84	30·6	15·8
Aug. i.	457	180	70	39·4	14·8	1620	478	150	28·9	9·2
1939										
Jan.	..... no shed material									
Feb. i.	6780	58	22	0·85	0·33	2462	25	7	1·01	0· 3
,, ii.	1142	32	17	2· 8	1· 5	585	22	12	3·76	2·06
Mar. i.	913	27	28	2·96	3·06	112	10	4	8· 9	3· 6
,, ii.	395	32	17	8· 1	3·96	105	26	14	24· 6	13· 3
Apr. i.	511	148	30	27· 0	5·94	216	71	36	32· 8	16· 6
,, ii.	1027	237	72	23·07	7·00	256	96	39	37· 5	15· 3
Decr. ii.	1748	700	152	40· 0	8· 6	1097	257	113	23· 3	10· 3
1940										
Jan. i.	7028	1517	726	21· 6	10· 3	4963	908	555	18· 8	11· 2
,, ii.	5210	212	57	4·06	4·09	3687	161	59	4· 3	1· 9
Feb. i.	793	47	20	5· 9	2·60	1068	51	13	4·77	1· 1
,, ii.	29	7	3	24· 0	10· 4	836	12	1	1· 4	0· 1

i & ii indicate fortnights.

lation for the period were 50.7 and 10.7 in buds and 55.0 and 11.6 in bolls. In 1939-40, again, the phases of shedding, damage and population were found taking identical trends as were noted in 1937-38 but the high figures of 1937-38 were never reached. Absence of shedding in the early months of growth and low incidence of bollworm in 1938-39 may be attributable to the continued drought experienced during that period. On the other hand, a high

incidence of the bacterial disease caused by *Bacteria malvacearum* was noted to have affected the buds and bolls in that season.

(*c*) *In green and dry bolls.* Though no actual examination was made in 1937-38 and 1938-39, figures for the earlier years have been compiled and are furnished in two separate tables hereunder (Tables II and III).

TABLE II

Percentages of *Earias fabia* and *E. insulana* in standing green bolls of Cambodia collected from 100 plants.

Year	Jany.	Feby.	March	April	May	June	July
1920	1·79	1·05	5·77	5·30	3·10	2·50	3·10
1922	3·27	1·14	0·29	5·37	18·32	13·13	7·19
1923	3·73	0·53	0·93	1·65	1·80		
1924	0·95	0·92	3·24	6·12	3·40		
1925	7·21	0·91	3·50	12·20	17·10		
1926	1·38	0·79	0·95	3·34	6·80	7·77	12·50
1927	1·44	2·23	3·45	7·40	11·64	10·50	6·64
1928	2·28	0·54	0·87	3·83	2·03		
1929	3·78	1·50	1·50	4·40			
1930	3·95	1·80	3·47	3·02			
1931	1·60	1·30	1·50	11·50			
1932	3·93	3·70	2·50	4·20			
1933	2·80	3·70	4·40	7·99	2·20	1·79	3·20
1934	1·38	0·68	0·71	14·80			

TABLE III

Dry boll infestation by *Earias fabia* and *E. insulana* in Cambodia cotton for the years 1922–1934.

Year	Bolls examined	Bolls damaged	Bolls damaged by Earias	Locks damaged by Earias	Total No. of locks	Percentage of lock damage
1922 Season	61211	6480	2742	3015	183633	1·6
1922 Kar	19972	15999	2597	3771	59916	6·3
1923	2599	379	111	120	8797	1·4
1924	863	213	61	75	2589	2·9
1925	1142	193	64	77	3426	2·3
1927	1045	232	80	99	3135	3·2
1928	1784	77	42	40	5352	0·9
1929	1343	167	88	136	4029	3·2
1931	2803	620	191	240	8409	2·9
1932	2477	812	205	370	7431	5·1
1933	3783	717	424	700	11349	6·3
1934 Season	840	654	260	608	2520	25·0
1934 Kar	1899	955	140	251	5697	4·6

It will be seen that the infestation in the green bolls in the months of January is always low scarcely exceeding 3.95% except

in one year (1925) when it shot upto 7.25%. It then steadily and slowly rises and reaches the peak by the end of April when the crop is, as a rule, pulled out on the farms and is no longer available for following up the trend of infestations in subsequent months. Nevertheless, the figures for four years which are available indicate that there is a tendency for infestation to go up beyond April. As regards the damage to locks in dry kapas it seldom exceeded over 6.0% though in one year (1933) as high a figure as 25.0% was recorded.

Nature and extent of damage

The caterpillars bore into the buds, flowers and bolls and feed on the inside contents of the ovaries. They sometimes totally destroy them or bring about shedding. Though an internal borer for most of its larval life the caterpillar has a tendency to withdraw and move out into another bud or boll. This habit which is in contrast with that of the pink bollworm is responsible for more widespread damage observable in the buds and bolls. It has already been mentioned that top boring of the stems is a feature in the early stages of the growth of the cotton. This kind of damage sometimes affects adversely the yields of certain types of cotton by delaying the flowering; it sometimes helps to give an increased yield as well, as noted elsewhere. Being a dirty feeder, the attacked boll even if it should persist cannot be expected to give clean lint when it finally bursts. To this extent the damage must be considered fairly heavy. More often the damaged bolls get hard, mummified and seldom open properly. From the incidence figures for shed buds and bolls it is clear that the spotted bollworms are active early in the season and bring about a severe shedding of the early formed flower buds. According to Hilson (1925) the buds that appear in the period from the middle December to late January are the most efficient in developing into good bolls. Unfortunately, this critical period synchronises with intense activity of the bollworms which results in more widespread attack and consequently more of shedding in this period. The loss under this head is considerable. If the bollworm factor is eliminated at this vulnerable stage and an increase in the stand of bolls secured there will ultimately be more yield at the end.

Alternate host plants

Both the species of moths were found breeding in *Abutilon indicum, A. hirtum, Hibiscus rosasinensis, H. cannabinus, H. esculentus, H. vitifolius, Malvastrum coromandelianum* and *Althoea rosea;* they are not noted on *Thespesia populnea, Sida cordifolia, Hibiscus panduriformis* and *H. subdarifa.* The caterpillars were found right through the year in varying proportions. From the studies made so far, *Hibiscus vitifolius* pods were found to be more heavily infested by the spotted bollworm, nearly 19.0% of the pods being found bored. *Abutilon* spp. are found to carry a larger population of *E. insulana* caterpillars and this finding is in agreement

with that of Fletcher and Misra (1921). Infestation percentages in the two host plants i.e., *H. vitifolius* and *Abutilon hirtum* over a period of four years are furnished in the table IV below.

Incidence of spotted bollworms in host plants

Year	Hibiscus vitifolius						Abutilon hirtum					
	Total examined	Total attack	Population E/b	Population E/i	%age of incidence	%age of larval population	Total examined	Total attack	Population E/b	Population E/i	%age of incidence	%age of population
1937	1169	229	189	8	19·6	16·8	906	145	27	31	16·0	6·4
1938	918	155	122	3	16·9	12·5	2748	319	34	195	11·8	8·5
1939	907	169	107	—	18·6	11·8	556	25	—	3	4·5	5·6
1940	767	148	111	—	19·1	14·5	not taken					

Natural enemies.

The caterpillars were found to be parasitised under the field conditions. A list of parasites so reared from the field material is given below.

Name	Nature of parasitism	Host and its stage	Plant host
BRACONIDAE			
Microbracon lefroyi D & G.	ecto	*E. fabia* and *E. insulana* caterpillars.	Shed cotton buds, flowers and bolls; *Hibiscus esculentus* pods.
Microbracon greeni (Ash)	ecto	do.	*Hibiscus vitifolius* pods; *Abutilon hirtum* & *A. indicum* pods.
Microbracon hebetor (Say)	ecto	*E. fabia* caterpillars.	*H. esculentus* pods.
Bassus n. sp.	endo	do.	Shed cotton buds, flowers and bolls.
Rhogas aligarhensi Quadri.	endo	do.	Shed cotton buds, flowers and bolls and *H. esculentus* pods.
ICHNEUMONIDAE			
Melcha nursei Cam.	endo	do.	*H. esculentus* pods.
CHALCIDAE			
Elasmus johnstoni Ferr.	ecto	*E. fabia* larvae and prepupae.	Shed cotton buds and bolls and *H. vitifolius* pods.
TACHINIDAE			
Actia hyalinata Mall.	endo	*E. fabia* larvae.	Shed cotton buds and bolls.
CHLOROPIDAE			
Polyodaspis compressiceps Duda.	endo	do.	*H. vitifolius* pods.

It will be seen that there are three kinds of Microbracons parasitising the caterpillars under field conditions. *Microbracon lefroyi* parasites which are characterised by the ebony black transverse bands on the 3rd and 4th abdominal segments seem to attack the caterpillars infesting cotton and *H. esculentus* only. They have not been bred so far from caterpillars in *H. vitifolius* and *Abutilon* spp. pods though the host population in the latter was always high and the host plants co-existed with cotton in certain cases and sometimes were situated far off from cotton. *Microbracon greeni* has been found to attack *E. fabia* caterpillars in *H. vitifolius* and *E. insulana* caterpillars in *Abutilon* pods but has never been reared so far from the cotton buds, flowers and bolls nor from *H. esculentus* pods. This behaviour and the disparity in size and color between the two strongly suggest that the two parasites are not identical as is inclined to be regarded by Lal (1939). Laboratory breeding trials have fully borne out the above assumption; the specificity of the parasites had never changed and they always bred true to type. *Microbracon lefroyi* was found to parasitise worms in tender buds, flowers and bolls. It was not much in evidence in well developed bolls. Its activity was evident at the time of heavy production of buds and bolls and it faded off when the budding slowed down. Breeding of this parasite which presented difficulty in the earlier years was made easy by giving caterpillars enclosed in partially cut tender bolls of 1 cm. to 2 cm. diameter, the contents of which were partially scooped out; the cut halves were then sealed with the caterpillar in, by means of a loop of thread. The caterpillars given in this way were easily accepted and parasitised. Further details on these parasites will form the subject matter for another paper which is to be published shortly.

It will be interesting to record that *Eumenes edwardsii* has been found to hunt *E. fabia* caterpillars and stock them in its nest built on the tops of trees.

Life history studies.

The two previously mentioned publications give details on the life history of the two species. It is not intended therefore to cover the same ground once again except where it is absolutely necessary. Both the species are nocturnal in habit. They pair on the 2nd day of emergence and soon after the females commence to lay eggs; egglaying is chiefly confined to the early hours of the night.

Eggs and egg period. Under field conditions the eggs are found all over the parts of the plant, more being observed in concealed situations like the leaf axils, bracts, leaf veins on the underside etc; they are never closely laid but are scattered loosely in twos and threes. Fresh eggs are of deep sky blue tint, with light green sheen at the top; they are of the shape of a crown and are highly sculptured. Within 12 to 20 hours after egglaying, the fertilised eggs develop a pink spot on the crown region and a pink annular band immediately below the crown; on the 2nd day the blue gloss changes to dull buff color but the pinkness of the band becomes very pronounced; on the 3rd day the egg shell becomes dull brown to white

and the developing larva is now visible underneath. Larval emergence is more restricted towards the crown region than towards the base. It takes nearly 60 to 72 hours for the eggs to hatch. Moths are capable of laying a maximum of 385 eggs spread over 5-13 days; their longevity does not exceed more than 15 days. The fresh hatchlings have the habit of partly nibbling the egg shell. The fecundity record for *E. fabia* is furnished below. There is not much of difference in the life history details in the two species.

Fecundity record of *Earias fabia*.

Serial No.	Date of emergence of moths.	Date of Egglaying	Total No. of eggs.	Egg laying period in days.	Longeviiy in days.
1.	4-3-33	6 7 8 9 10 11 12 1 35 54 45	135	4	8
2.	25-3-33	26 27 28 29 30 31 1 2 3 40 82 62 74 33 17 3	311	7	11
3.	27-3-33	29 30 31 1 2 3 10 28 45	83	3	8
4.	10-4-33	12 13 14 15 16 17 84 69 62 35 13	263	5	8
5.	16-4-33	20 21 22 23 24 25 26 27 28 29 58 54 44 39 36 21 22 15	289	8	14
6.	18-4-33	20 21 22 23 24 25 26 27 28 55 42 38 27 38 24 18 9	246	8	11
7.	18-4-33	19 20 21 22 23 24 65 22 8	95	3	8
8.	19 4-33	21 22 23 24 25 26 27 28 29 39 40 39 27 22 26 17 16 9	235	9	12
9.	20-4-33	21 22 23 24 50 66 72	188	3	5
10.	20-4-33	20 21 22 23 24 25 26 15 89 68 60 24 2 9	267	7	8

Larval and pupal periods.—The larval life extends over a period of 10-12 days after which the larvae spin the cocoons and pupate therein; the prepupal period lasts for about 24-36 hours. In the publications so far cited there is no mention made of the characters by which one could distinguish one species from the other in their larval stages. It is possible to distinguish the caterpillars of the two species from the 3rd instar stages. The larvae of *E. insulana* apart from their paleness in color and more extensive creamy color in their body possess well defined finger shaped processes which are wanting in *E. fabia caterpillars*. A description of the

advanced *E. insulana* caterpillars is given. *Head*: Clypeus white, two semi lunar smoky black patches on the front united; *Prothorax*: a pair of transverse stripes light black; the anterior bolder and well defined but broken in the middle; an inverted V-black mark in the centre in front of the first stripe; spiracle black. *Mesothorax*: dull olive with creamy white patches interspersed; two pairs of finger shaped processes, one median and the other lateral; the median 2.5 mm. twice as long as the lateral, purplish, topped by single white hair and covered with a felt of purplish hairs; base and the bottom broadly orange. The lateral, white small covered with a felt of white hairs and topped by single white hair; basal end with an orange patch; a big black oval spot between each patch on either side. *Metathorax*: similar to meso but in the lateral pair of processes bigger than that of the meso. *First abdominal segment*: white patches more extensive; two pairs of equal sized processes, one median and the other lateral with white felt of hairs on both; the bases orange; the lateral placed immediately above the black spiracle. *Second abdominal segment*: with only one well developed pair which is lateral, placed below and behind the spiracle; two pairs of big black round patches, one median and the other lateral; the median pair of processes reduced to stumps. *Third abdominal segment*: very much like the first but with a larger white area. *4th, 5th, 6th and 7th abdominal segments*: with the same number of processes as the 2nd and 3rd; the fourth has a large white area with less of black spotting. *8th and 9th abdominal segments*: same as above, the 9th having a median area which is distinctly black and warty. *10th abdominal segment*: median area with a conspicuous shining black warty surface. *Legs*: with a black touch at the coxal end. Pupation is partially on the plant and partially in the soil debris containing shed material. Adults emerge in 7-10 days after pupation. There is so far no indication that long cycle pupae do exist.

Adult emergences and sex ratio.

It has often been observed that, for some reason or other, a few pupae get mummified and there was no emergence of adults from them. The time of emergence is usually restricted to the early hours of the morning between 3-5 a.m. It would appear that the females slightly predominated in number over the males. Out of 138 adults reared in 1933 over a period of two months in March and April, 66 happened to be males, the rest being females.

Non-response to tropisms.

The moths are not usually well attracted to powerful light; nor do they come to traps which are charged with odorous chemicals like oils of Citronella, Geranium, Anisi, bergamol and terpenes like Eugenol, Iso Eugenol, etc. Gingelly oil cakes seem to show very slight attractiveness when soaked in water and exposed in shallow trays in the cotton fields.

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BIRD LIFE IN AN ASSAM JUNGLE

BY

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This paper is intended to give some account of the bird life of a small stretch of country, which I was able to study fairly intensively over a period of three months, from mid-February to mid-May.

The locality was the Jagi Road quarry, lying on the Assam Trunk Road, halfway between Gauhati and Nowgong, just where the first ridges of the Khasia Hills begin to rise from the dead level plains of the Brahmaputra valley.

The particular area under review is bounded on the north by the Trunk Road, and is about $1\frac{1}{2}$ miles in length by $\frac{3}{4}$ mile in breadth. It consists of a strip of flat ground varying in width from 200 yards to $\frac{1}{4}$ mile, behind which rises a forested ridge 200 feet high, dropping on the far side to plains level, where a brook forms the southern boundary. To the north, beyond the main road, the plains extend 15 miles or more to the Brahmaputra, a vast expanse of tall thatching grass, swampy 'bhils', and a certain amount of paddy cultivation. To the south the land rises in a series of forest clad ridges, with a general east to west trend, as far as the eye can reach. All this is reserved forest and quite uninhabited. Malaria is very prevalent, and the population, even in the plains, small.

Climate. I was unable to obtain any rainfall figures, but, judging from the vegetation, it is likely to be in the neighbourhood of 80/90 inches. During the period under consideration rain fell, on an average, 3 times a week, usually in the form of heavy thunderstorms during the night, often accompanied by a strong wind. At the time of my arrival in February, the air was comparatively dry with a sharp drop of temperature at night. By the middle of May, it was hot, humid, and steamy both day and night.